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The Accelerating Universe: Insights From Astronomical Scales To Heliospheric Boundaries

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Abstract
The accelerating expansion of the universe is one of the most interesting discoveries in cosmology. It can be summarized by a few key points:
- The Discovery: In the late 1990s, two independent research teams studying distant Type Ia supernovae discovered that the universe's expansion rate is not slowing down, as previously thought, but is actually accelerating. This was a groundbreaking revelation that earned the 2011 Nobel Prize in Physics.
- Dark Energy: This accelerated expansion is attributed to a mysterious force called dark energy, which makes up about 68% of the universe. Unlike gravity, which pulls objects together, dark energy seems to have a repulsive effect, driving the accelerated expansion.
-. The Big Rip: One of the potential scenarios for the ultimate fate of the universe is the "Big Rip." In this scenario, dark energy continues to accelerate the expansion to the point where galaxies, stars, and even atomic particles are torn apart. This would result in a cold, dark, and empty universe.
-. Ongoing Research: The study of the accelerating universe is a vibrant field of research. Scientists are using advanced telescopes and space missions to gather more data about dark energy, cosmic inflation, and the large-scale structure of the universe. Projects like the Dark Energy Survey and the Euclid mission aim to shed light on these mysteries.
The discovery of the accelerating universe has opened up new frontiers in our understanding of cosmology. There's so much more to explore, and each new finding brings us closer to unraveling the secrets of the cosmos.
The nature of dark energy remains one of the biggest mysteries in physics. Is it a cosmological constant, or does it vary over time?
How does dark energy interact with other components of the universe, such as dark matter?
Are there modifications to general relativity needed to explain cosmic accelerati

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I. Introduction

The accelerating expansion of the universe is one of the most significant discoveries in modern cosmology. It refers to the observation that the universe is not only expanding but also doing so at an increasing rate. This phenomenon was first discovered in 1998 through observations of distant Type I-a supernova, which serve as "standard candles" for measuring cosmic distances.

Edwin Hubble discovered in the 1920s that galaxies are moving away from us, and the farther away they are, the faster they recede. Hubble’s Law describes this relationship.

Initially, scientists expected the expansion of the universe to slow down over time due to the gravitational pull of matter. However, observations of distant supernovae showed that the expansion is actually speeding up.

The leading explanation for the accelerating expansion is the presence of dark energy, a mysterious form of energy that permeates space and exerts negative pressure, causing the universe to expand faster. Dark energy is thought to make up about 68% of the total energy content of the universe.

Observations of the CMB (Cosmic Microwave Background), the afterglow of the Big Bang, provide additional evidence for dark energy. The CMB data, combined with measurements of large-scale structure and supernovae, support the idea of an accelerating universe.

Evidence for Accelerating Expansion:
-Type I-a Supernova: These supernovae have a consistent peak brightness, making them ideal for measuring distances. Observations show that distant supernovae are dimmer than expected, indicating they are farther away than predicted in a decelerating universe.
-Baryon Acoustic Oscillations (BAO): These are regular fluctuations in the density of visible matter in the universe, serving as a "ruler" for measuring cosmic distances.

-Weak Gravitational Lensing: The distortion of light from distant galaxies by intervening matter provides insights into the distribution of dark energy.

The accelerating expansion challenges our understanding of fundamental physics, particularly the nature of dark energy and its interaction with gravity.

It also raises questions about the ultimate fate of the universe and the possibility of other, unknown forces at play.

The discovery of the accelerating expansion of the universe earned Saul Perl mutter, Brian Schmidt, and Adam Riess the 2011 Nobel Prize in Physics. It remains a central focus of cosmological research today.

I-*Physics Equations and Formulas;*

E = mc^2.

$A_{\text{current}} = \frac{c^2 \times \sqrt{m}}{t}$.

$V_{\text{voltage}} = \sqrt{m}$.

$w_{\text{Power}} = \frac{E}{t} = \frac{\text{m}c^2}{t} = \text{current} \times \text{voltage}$.

Elementary charge: $e = 1.602176634 \times 10^{-19}$ c

G: the gravitational constant = 6.67408$\times 10^{-11}\ m^3 Kg^{-1} S^{-2}$

C: Speed of light

$Ç = \frac{e^2}{\alpha \times 4 \times \pi \times \hbar \times \varepsilon_0} = 299792457{,}928\ {}^{m}/_{s}$ (May 20, 2019)

Vacuum permittivity: ε_0= 8.85418781762039$\times 10^{-12}\ Kg^{-1} m^{-3} s^4 A^2$

II- The fine structure constant:

The elementary charge and the Planck charge are both fundamental quantities related to electric charge, but they arise in different contexts and have different physical meanings. Here is a detailed comparison:

A-Elementary Charge (e)

Definition:

The elementary charge (e) is the electric charge carried by a single proton or the negative of the charge carried by a single electron.

It is the smallest unit of electric charge observed in nature and is considered a fundamental physical constant.

Time:

The SI base units defined in the International System of Quantities have been redefined in terms of natural physical constants in of May 20, 2019, [7.8.9.10].

Value :

$e = 1{,}602176634 \times 10^{-19}$ Coulombs (c)

Signifiance :

The elementary charge is the building block of electric charge in the Standard Model of particle physics.

All observed charges in nature are integer multiples of e (quarks have fractional charges, but they are always combinations of ±13e±31e or ±23e±32e).

Context:

The elementary charge is directly measurable in experiments, such as the Millikan oil-drop experiment.

B- Planck Charge (q_p)

Definition:

The Planck charge is a derived unit of electric charge in the system of Planck units, which are natural units based on fundamental constants like the speed of light (c), Planck's constant ($\hbar$), and the gravitational constant (G).

Time:

$end\ of\ the\ triassic\ era = \left(\frac{\alpha \times \hbar \times c^2}{2 \times \pi \times e^2}\right) = 4.2942106 \times 10^{17}\ seconds.$

$= 13607904963.1\ years\ after\ big - bang$. [1]. |3]

Formula :
The Planck charge is defined as:

$$q_p = \sqrt{4 \times \pi \times \varepsilon_0' \times \hbar \times c}$$

Where:
- ε_0' the vacuum permittivity in the end of the Triassic era, |1] |2]|3]
- $\hbar$ is the reduced Planck constant,
- c is the speed of light in the end of the Triassic era .[1]|2]|3]

Value :
$q_p = 1{,}875546035270512 \times 10^{-18} c$

Signifiance :
The Planck charge is a theoretical construct used in the context of quantum gravity and unified theories.
It represents the scale at which quantum effects and gravitational effects become comparable.

Context:
The Planck charge is not directly measurable in experiments. It is used in theoretical physics, particularly in discussions of the Planck scale, where quantum mechanics and general relativity are expected to unify.

Relationship Between the Two
- The Planck charge is much larger than the elementary charge:

q_p≈11.7 e.
- The ratio of the Planck charge to the elementary charge is related to the fine-structure constant (α), which characterizes the strength of the electromagnetic interaction:

Where α exactly equal:

$$\alpha = 7{,}297352588803237 \times 10^{-3}$$

The elementary charge is a fundamental, measurable quantity that defines the charge of particles such as protons and electrons. While the Planck charge is a theoretical quantity used in the context of Planck units and quantum gravity, it represents a much broader range of charges.

While the elementary charge is rooted in experimental observations, the Planck charge is a theoretical tool for exploring the unification of fundamental forces.

III-the parsec at the end of the Triassic era;

The parsec is a fundamental unit of distance in astronomy, defined based on the parallax method. It provides a convenient way to express the vast distances between celestial objects, bridging the gap between the astronomical unit (AU) and light-years

A parsec (short for "parallax second") is a unit of distance used in astronomy to measure the vast spaces between celestial objects outside our solar system. One parsec is equivalent to approximately 3.26 light-years, or about 31 trillion kilometers (19 trillion miles).

The name "parsec" comes from the method of measuring this distance: the parallax angle. By observing the apparent shift in position of a nearby star against the background of more distant stars from two different points in Earth's orbit around the Sun (six months apart), astronomers can calculate the star's distance using geometry.

In simpler terms, if a star has a parallax angle of one arc second (1/3600th of a degree), it is exactly one parsec away from us.

The parsec is particularly useful in astronomy because it is directly tied to the method of stellar parallax, which is one of the most reliable ways to measure distances to nearby stars. As the Earth orbits the Sun, nearby stars appear to shift slightly against the background of more distant stars. By measuring this angular shift (parallax angle), astronomers can calculate the distance to the star using the parsec as a unit.

Examples of Distances in Parsecs:
The nearest star to the Sun, Proxima Centauri, is about 1.3 parsecs away.
The center of our galaxy, the Milky Way, is about 8,000 parsecs (or 8 kilo parsecs) from Earth.
The Andromeda Galaxy, the nearest spiral galaxy to the Milky Way, is about 780 kilo parsecs away.
Larger Units:
For even greater distances, astronomers use:
Kilo parsec (kpc): 1,000 parsecs.
Mega parsec (Mpc): 1,000,000 parsecs.
Giga parsec (Gpc): 1,000,000,000 parsecs.

These units are commonly used to describe distances between galaxies and the large-scale structure of the universe.
The basic unit (the parsec) at the end of the Triassic period is equal to:

$$1pc = \left(\frac{c^3 \times \hbar}{16 \times e^2} \times \sqrt{\frac{\alpha^9}{\pi^7}}\right) = \left(\frac{c^2}{64 \times \varepsilon_0'} \times \sqrt{\frac{\alpha^7}{\pi^9}}\right) = \left(\frac{e^4}{1024 \times \hbar^2 \times \varepsilon_0'^3} \times \sqrt{\frac{\alpha^3}{\pi^{13}}}\right) = \left(\frac{\varepsilon_0' \times c^4 \times \hbar^2}{4 \times e^4} \times \sqrt{\frac{\alpha^{11}}{\pi^5}}\right)$$
$$= 3{,}055755408240171 \times 10^{16} meter$$

Where:

$$\varepsilon_0{}' = \left(\frac{\mathrm{e}^2}{4 \times \pi \times \hbar \times \alpha \times \mathrm{c}}\right) = 8{,}8480624 \times 10^{-12} \mathrm{Kg}^{-1}\mathrm{m}^{-3}\mathrm{s}^4\mathrm{A}^2$$
$$\mathrm{c} = 3 \times 10^8 \ \mathrm{m}/_\mathrm{s}$$ |2]

<u>IV- the end of the Triassic period</u> <u>about 199 million years:</u>

The end of the Triassic era, around 199 million years ago, was marked by a significant extinction event known as the End-Triassic Extinction. This event led to the disappearance of about 76% of all marine and terrestrial species and around 20% of all taxonomic families.
End of the Triassic era $= \left(\frac{\alpha \times \hbar \times c^2}{2 \times \pi \times e^2}\right) = 4.2942106 \times 10^{17}\ seconds$
$= 13607904963.1\ years\ after\ big - bang$. [1.3]

<u>V- Hubble's constant at the end of the Triassic era:</u>

Hubble's constant (H_0) is a fundamental parameter in cosmology that quantifies the rate at which the universe is expanding. It is named after Edwin Hubble, who first observed the expansion of the universe in the 1920s. Hubble's constant relates the recession velocity of galaxies to their distance from us,

The Hubble's constant at the end of the Triassic era:

$$H_0 = \left(\sqrt{\frac{c^2 \times \alpha^7}{64 \times \pi^5}}\right) = \left(\frac{e^2}{32 \times \hbar \times \varepsilon_0'} \times \sqrt{\frac{\alpha^5}{\pi^7}}\right) = \left(\frac{\alpha^3}{16 \times \pi^3} \times \sqrt{\frac{c \times e^2}{\hbar \times \varepsilon_0'}}\right)$$
$$= \left(\frac{\alpha^2 \times e^2}{64 \times \pi^4 \times \hbar \times \varepsilon_0' \times c} \times \sqrt{\frac{c \times e^2}{\hbar \times \varepsilon_0'}}\right) = 0{,}07115988597 \frac{m}{s.parssec}$$
$$=71{,}\ 15988597 \frac{Km}{s.Mpc}$$

Acceleration:

$$M_0 = \left(\frac{e^2}{4 \times \hbar \times c} \times \sqrt{\frac{\alpha^5}{\pi^3}}\right) = \left(\frac{e^4}{16 \times \hbar^2 \times c^2 \times \varepsilon_0'} \times \sqrt{\frac{\alpha^3}{\pi^5}}\right) = \left(\varepsilon_0' \times \sqrt{\frac{\alpha^7}{\pi}}\right)$$
$$= 1{,}65711217 \times 10^{-19} \frac{m}{s^2.parssec}$$
$$= 1{,}65711217 \times 10^{-16} \frac{Km}{s^2.Mpc}$$

Where:

$$\varepsilon_0{}' = \left(\frac{e^2}{4 \times \pi \times \hbar \times \alpha \times c}\right) = 8{,}8480624 \times 10^{-12} Kg^{-1}m^{-3}s^4A^2$$
$$c = 3 \times 10^8 \ m/_s$$

<u>VI- Astronomical unit at the end of the Triassic period:</u>

An Astronomical Unit (AU) is a unit of measurement used primarily in astronomy to describe the average distance between the Earth and the Sun. To put it in perspective. It's a handy reference point for measuring distances within our solar system.
The use of AU helps astronomers communicate vast distances without resorting to extremely large numbers.

The astronomical unit provides a convenient way to express and compare distances between celestial objects, such as planets, moons, and comets, relative to the scale of the solar system.

The AU is widely used in planetary science and astrophysics because it simplifies calculations and comparisons of distances on a solar system scale. For larger distances, such as those between stars or galaxies, astronomers use units like light-years or parsecs

$$AU_{moy} = \left(\frac{c^3 \times \hbar}{16 \times e^2} \times \sqrt{\frac{\alpha^9}{\pi^7}}\right) \times \left(\frac{\pi}{648000}\right) = 1{,}48147202404 \times 10^{11} m$$

VII- The beginning of the Jurassic era:

The transition between the Triassic and Jurassic era, often involves major changes in Earth's climate, geography, and biodiversity. These changes can be caused by a variety of factors, including radioactivity, changes in sea levels, and shifts in continental plates. For example, the end of the Triassic led to a mass extinction event that paved the way for dinosaur dominance in the Jurassic. During these transitions, ecosystems underwent dramatic changes. Species that were dominant in one era may decline or become extinct, while new species evolve and flourish in the next. This dynamic process of extinction and evolution is a natural part of Earth's history, and drives the diversity of life we see today.

Cosmic radiation between these two eras had profound and long-lasting effects on the environment and living organisms. The shock waves and heat generated by the radiation caused widespread destruction of infrastructure and landscapes.

$t_f = \left(\frac{\alpha^5 \times c}{64 \times \pi^4 \times \varepsilon_0''}\right) = \left(\frac{\alpha^5 \times ç'}{64 \times \pi^4 \times \varepsilon_0'}\right) = 110003{,}49\ s = 30{,}556 hours$ After the end of the Triassic era, |2]

VIII- Hubble's constant at the beginning of the Jurassic era:

$$\mathrm{H}_0 = \left(\sqrt{\frac{ç'^2 \times \alpha^7}{64 \times \pi^5}}\right) = \left(\frac{e^2}{32 \times \hbar \times \varepsilon_0''} \times \sqrt{\frac{\alpha^5}{\pi^7}}\right) = \left(\frac{\alpha^3}{16 \times \pi^3} \times \sqrt{\frac{ç' \times e^2}{\hbar \times \varepsilon_0''}}\right)$$

$$= \left(\frac{\alpha^2 \times e^2}{64 \times \pi^4 \times \hbar \times \varepsilon_0'' \times ç'} \times \sqrt{\frac{ç' \times e^2}{\hbar \times \varepsilon_0''}}\right) = 0{,}06955389846 \frac{\mathrm{m}}{\mathrm{s.\,parssec}}$$

$$=69,\ 55389846 \frac{\mathrm{Km}}{\mathrm{s.Mpc}}$$

Deceleration:

$$M_0 = -\left(\frac{2 \times e^2 \times (1-9\alpha)}{\hbar \times ç' \times (1-7\alpha)} \times \sqrt{\frac{\pi^3}{\alpha^3}}\right) = -\left(\frac{e^4 \times (1-9\alpha)}{2 \times \hbar^2 \times ç'^2 \times \varepsilon_0'' \times (1-7\alpha)} \times \sqrt{\frac{\pi}{\alpha^5}}\right) =$$

$$-\left(\frac{8 \times \varepsilon_0'}{(1-\alpha)} \times \sqrt{\frac{\pi^5}{\alpha}}\right) = -\left(\frac{8 \times c' \times \varepsilon_0''}{c \times (1-\alpha)} \times \sqrt{\frac{\pi^5}{\alpha}}\right) = -1{,}46019549 \times 10^{-8}\ \frac{m}{s^2.parssec}$$

$$= -1{,}46019549 \times 10^{-5}\ \frac{Km}{s^2.Mpc}$$

Where:

$ç' = \left(\frac{e^2}{4 \times \pi \times \alpha \times h \times \varepsilon_0}\right) - \left(\frac{3 \times e^2}{2 \times h \times \varepsilon_0}\right) = 293229384{,}143\ ^{m}/_{s}$ [1].

$\varepsilon_0'' = \left(\frac{e^2}{(4\pi) \times \hbar \times \alpha \times ç'}\right) = \left(\frac{\varepsilon_0}{1-3\alpha}\right) = \left(\varepsilon_0' \left(\frac{\alpha\pi}{1-\alpha} + 1\right)\right) = \left(\left(\frac{e^2}{4 \times \hbar \times c \times (1-\alpha)}\right) + \left(\frac{e^2}{(4\pi) \times \hbar \times \alpha \times c}\right)\right) = 9{,}0523627 \times 10^{-12} \mathrm{Kg}^{-1}\mathrm{m}^{-3}\mathrm{s}^4\mathrm{A}^2$[2]

$$\varepsilon_0 = 8{,}85418781762039 \times 10^{-12} \mathrm{Kg}^{-1}\mathrm{m}^{-3}\mathrm{s}^4\mathrm{A}^2$$

IX- Redefinition of the SI Base Units (May 20, 2019):

The redefinition of the four SI base units in May 20, 2019 marked a significant milestone in metrology, the science of measurement. This change aimed to base the International System of Units (SI) on fundamental constants of nature, ensuring greater stability and universality. Here's a breakdown of the redefined units and the constants they are now tied.

Advances in technology allowed scientists to measure these constants with unprecedented accuracy, making the new definitions more precise.

The redefinition did not change the actual size of the units but ensured their definitions are based on unchanging natural phenomena. This shift allows for more accurate and consistent measurements across science, and technology.

The 2019 redefinition was the culmination of decades of research and collaboration among scientists worldwide. It built on earlier redefinitions of the second (based on the cesium atom's vibration), the meter (based on the speed of light), and the candela (based on luminous efficacy). The 26th General Conference on Weights and Measures (CGPM) unanimously approved the changes, reflecting global consensus on the importance of this advancement.

This redefinition represents a profound shift in how humanity defines and measures the physical world, emphasizing the role of fundamental constants in our understanding of nature. [4.5.6].

X-The age of the universe (May 20, 2019);

On this day, the age of the universe is:

$$T = \left(\frac{\alpha \times ç}{4\times\pi^2\times\varepsilon_0}\right) = \left(\frac{e^2}{16\times\pi^3\times\hbar\times\times\varepsilon_0^2}\right) = \left(\frac{\alpha^2\times ç^2\times\hbar}{e^2\ \times\pi}\right) = 6{,}2586053\times10^{15}s[1]|2]$$

$$= 198328665{,}11\text{years after the Triassic} - \text{Jurassic extinction}, [4.5]$$

$$\left(\frac{\alpha\times c^2\times\hbar}{e^2\ \ \times(2\pi)}\right) + \left(\frac{\alpha\times ç}{4\times\pi^2\times\varepsilon_0}\right) = 4{,}3567967\times10^{17}s$$

$$= 13806233487{,}7\ years\ after\ big - bang\ .\ [1.3]$$

XI- Hubble’s constant (May 20, 2019):

The value of the Hubble constant has been improved over the years, but there is still some tension between the different measurement methods:

-Local measurements: Using nearby objects such as Cepheid variable stars and Type I-a supernovae, the Hubble constant has been measured to be about 73 km/s/Mpc.

-Cosmic microwave background (CMB): Measurements from the Planck satellite, which studies the early universe, give a lower value of about 67.4 km/s/Mpc. This discrepancy is known as the Hubble tension and is an active area of research in cosmology.

The Hubble constant is crucial to determining the age and size of the universe. The inverse of Hubble constant gives an estimate of the Hubble time, which is roughly the age of the universe.

It is also used to calculate the critical density of the universe, which determines whether the universe will expand forever or eventually collapse.

Measuring distances to astronomical objects accurately is difficult, especially for distant galaxies. Different approaches (such as Cepheid variables, Type I-a supernovae, and red giant stars) can yield slightly different results.

The Hubble tension suggests that there may be new physics beyond the standard cosmological model (ΛCDM) that we do not yet understand.

The discrepancy between local and cosmic microwave background measurements of H0H0 is one of the most intriguing puzzles in modern cosmology. Possible explanations include:

- Systematic errors in the measurements.
- New physics, such as additional neutrino species or modifications to dark energy.

The Hubble constant remains a cornerstone of cosmology, and resolving the Hubble tension could lead to breakthroughs in our understanding of the universe.

The Hubble's constant (May 20, 2019);

$$H_0 = \left(\sqrt{\frac{ç^2\times\alpha^7}{64\times\pi^5}}\right) = \left(\frac{e^2}{32\times\hbar\times\varepsilon_0}\times\sqrt{\frac{\alpha^5}{\pi^7}}\right) = \left(\frac{\alpha^3}{16\times\pi^3}\times\sqrt{\frac{ç\times e^2}{\hbar\times\varepsilon_0}}\right)$$

$$= \left(\frac{\alpha^2\times e^2}{64\times\pi^4\times\hbar\times\varepsilon_0\times ç}\times\sqrt{\frac{ç\times e^2}{\hbar\times\varepsilon_0}}\right) = 0{,}07111065707\,\frac{\text{m}}{\text{s. parssec}}$$

$=71,\ 11065707\ \frac{\text{Km}}{\text{s.Mpc}}$

Acceleration:

$$M_0 = \left(\frac{3 \times \varepsilon_0}{2} \times \sqrt{\frac{\alpha^7}{\pi}}\right) = \left(\frac{3 \times e^2}{8 \times \hbar \times ç} \times \sqrt{\frac{\alpha^5}{\pi^3}}\right) = \left(\frac{3 \times e^4}{32 \times \hbar^2 \times ç^2 \times \varepsilon_0} \times \sqrt{\frac{\alpha^3}{\pi^5}}\right) =$$

$$= 2{,}487389 \times 10^{-19}\ \frac{m}{s^2.\text{parssec}}$$

$$= 2{,}487389 \times 10^{-16}\ \frac{Km}{s^2.\text{Mpc}}$$

Where:
$ç = 299792457{,}928\ {}^{m}/_{s}$ (May 20, 2019)
$\varepsilon_0 = 8{,}85418781762039 \times 10^{-12} Kg^{-1} m^{-3} s^4 A^2$(May 20, 2019)
The Planck's constant $\hbar = 1{,}054571818 \times 10^{-34} J.s$ (May 20, 2019)

XII- The parsec (May 20, 2019):

$$1pc' = \left(\frac{c^3 \times \hbar}{16 \times e^2} \times \sqrt{\frac{\alpha^9}{\pi^7}}\right) + \left(\frac{ç^3 \times \hbar}{12 \times e^2} \times \sqrt{\frac{\alpha^{11}}{\pi^7}}\right) =$$

$$\left(\frac{c^2}{64 \times \varepsilon_0'} \times \sqrt{\frac{\alpha^7}{\pi^9}}\right) + \left(\frac{ç^2}{48 \times \varepsilon_0} \times \sqrt{\frac{\alpha^9}{\pi^9}}\right) =$$

$$\left(\frac{e^4}{1024 \times \hbar^2 \times \varepsilon_0'^3} \times \sqrt{\frac{\alpha^3}{\pi^{13}}}\right) + \left(\frac{e^4}{768 \times \hbar^2 \times \varepsilon_0^3} \times \sqrt{\frac{\alpha^5}{\pi^{13}}}\right)$$

$$= \left(\frac{\varepsilon_0' \times c^4 \times \hbar^2}{4 \times e^4} \times \sqrt{\frac{\alpha^{11}}{\pi^5}}\right) + \left(\frac{\varepsilon_0 \times ç^4 \times \hbar^2}{3 \times e^4} \times \sqrt{\frac{\alpha^{13}}{\pi^5}}\right) = 3{,}0854256 \times 10^{16} meter$$

XIII- Astronomical unit (May 20, 2019):
$AU'_{moy} = (1pc') \times \left(\frac{\pi}{648000}\right) = 1{,}49585656433 \times 10^{11} m.$

XIV-The speed of the Earth's movement away from the sun:

The Earth is very slowly moving away from the Sun, but the distance change is extremely small and occurs over vast timescales. This phenomenon is primarily due to two factors:

Tidal Interactions and Angular Momentum: The Sun is gradually losing mass through solar wind and radiation. As it loses mass, its gravitational pull on the Earth weakens slightly, causing the Earth to drift outward. Additionally, tidal interactions between the Earth and the Sun transfer angular momentum, contributing to this outward movement.

Expansion of the Sun: Over billions of years, the Sun will evolve into a red giant, expanding in size. While this expansion will significantly affect the Earth's orbit in the distant future, it is not the primary reason for the current slow outward drift.

The rate at which the Earth is moving away from the Sun is estimated to be about 1.5 centimeters per year. While this is measurable, it is negligible on human timescales and does not significantly impact Earth's climate or habitability in the near future.

$$v = \left(\frac{(AU'_{moy}) - (AU_{moy})}{T}\right) = 2{,}29836195 \times 10^{-7}\ {}^{m}/_{s}$$

$$v' = v \times \left(\frac{365{,}2425 \times 24 \times 3600}{16 \times \pi^3}\right) = v \times \left(\frac{(365{,}2425 \times 24 \times 3600) \times e^2}{64 \times \pi^4 \times \hbar \times \varepsilon_0 \times ç \times \alpha}\right) = 0{,}01461988214\ {}^{m}/_{year}$$

Where:$\left(\frac{365{,}2425 \times 24 \times 3600}{16 \times \pi^3}\right) = 63610{,}00775 s$ the time it takes light to travel from the Sun to the edges of the solar system (The heliosphere ray).

XV-The Solar System ray or the heliosphere ray (May 20, 2019):

In astrophysics, the ray of the Solar System depends on how you define its boundaries. The Solar System is vast, and its size can be measured in different ways based on the observable objects or phenomena we consider as its edge.

Also, the time it takes for light to travel from the Sun to the edges of the Solar System can vary greatly depending on how we define the boundary.

$$time = \left(\frac{(365{,}2425 \times 24 \times 3600)}{16 \times \pi^3}\right) = 63610{,}00775s$$

$$ray = \text{ç} \times \left(\frac{(365{,}2425 \times 24 \times 3600)}{16 \times \pi^3}\right) = 19069800509{,}6Km$$

II. Conclusion:

The accelerating expansion of the universe is one of the most profound discoveries in modern cosmology. It refers to the observation that the universe is not only expanding but also doing so at an increasing rate over time. This discovery has revolutionized our understanding of the cosmos and introduced new mysteries, such as the nature of dark energy.

In unraveling the intricate dynamics of the accelerating universe, this study bridges the vast scales of cosmic expansion with the localized phenomena of our solar system. By integrating parsecs, Hubble's constant, astronomical units, and the heliosphere boundaries into a cohesive framework, a richer understanding of cosmic acceleration emerges. These findings not only highlight the interconnectedness of astronomical metrics but also invite further inquiry into the intricate tapestry of the universe's expansion. As we continue to refine our tools and expand our perspectives, the mysteries of the cosmos remain a boundless frontier, urging us to explore deeper, think broader, and marvel at the extraordinary journey of the universe.

The accelerating expansion of the universe is a reminder of how much we still have to learn about the cosmos. It is both to think about the mysteries that lie beyond our current understanding.

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